Low-Cost Combustion Devices Component Design Verification

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A test program designed to evaluate the performance of ultra-low-cost combustion chambers and injectors is continuing at MSFC. Future combustion devices manufactured using the techniques demonstrated during this program can result in thrust chamber assemblies costing a fraction of previous designs.

Private industry approached NASA/ MSFC's Propulsion Laboratory looking for innovative ways to reduce future propulsion system costs. Historically, the thrust chamber, nozzle, and injector (known as the thrust chamber assembly) represent 37 percent of total engine unit cost. Several different design approaches were evaluated as a means of reducing this ratio. The two approaches selected as having the highest potential for cost savings were a film-cooled ablative combustion chamber and a simplified design concept for impinging injectors. Both of these concepts would be brought together for unified testing in the breadboard "Fastrak" engine.

In-house engineering and manufacturing resources were used to produce the critical parts for the Fastrak engine. MSFC personnel designed and fabricated ablative-type combustion chamber liners for use in hardware specifically modified for this test program. A like-on-like, monolithic injector face was also designed and manufactured to operate with the selected propellant combination.

Hot-fire testing of the engine began in September 1994 (fig. 37) to evaluate interaction of the two design approaches in a combustion environment using liquid oxygen and kerosene propellants. Two primary objectives of the test program include demonstrating the durability of ablative thrust chambers and monitoring the effects of film cooling on erosion rates. The latter objective is critical because of the potential for performance degradation due to throat erosion during engine operation. Injector efficiency and wall compatibility are also being evaluated to ensure performance goals are achieved.

Twenty tests have been conducted at chamber pressures up to 500 pounds per square inch absolute, with durations to 60 seconds. To date, erosion rates in the throat region (the area of greatest concern) have been insignificant (with film-cooling levels of 10 to 13 percent), and injector efficiency is approximately 94 percent. The remaining tests will focus on lower film coolant flow rates and very long duration firings (up to 250 seconds) to establish chamber liner longevity.

The early successes of the Fastrak program prompted the next step in the evolution of this technology. A new, much larger, thrust chamber assembly was designed and built at MSFC this year. Aptly named "Fastrak II," it

FIGURE 37.—Fastrak fire testing.

incorporates the same design philosophy as its breadboard predecessor, but creates a flight-type thrust chamber assembly (fig. 38). Fastrak II was designed to produce 40,000 pounds of thrust at altitude and operate with the same propellant combination as Fastrak. Advanced composite material manufacturing techniques used by MSFC's Materials and Processes Laboratory and its contractor were used to construct the integral thrust chamber/nozzle assembly. This time, the liner uses a thin, lightweight carbon filament wrap on the exterior as a structural close-out of the pressure vessel. The Fastrak II injector design reduces to just five the hundreds of parts usually required for injectors. In-house conventional machining was used to produce the five-piece design. The Fastrak II thrust chamber assembly is 82 inches tall and 46 inches in diameter. It will be tested in test stand 116 beginning in September 1995. Data gathered from both of these test articles are considered essential to the successful development of the low-cost propulsion system for the Orbital Sciences Corporation X–34/OV–1, for which MSFC has design and test responsibilities.

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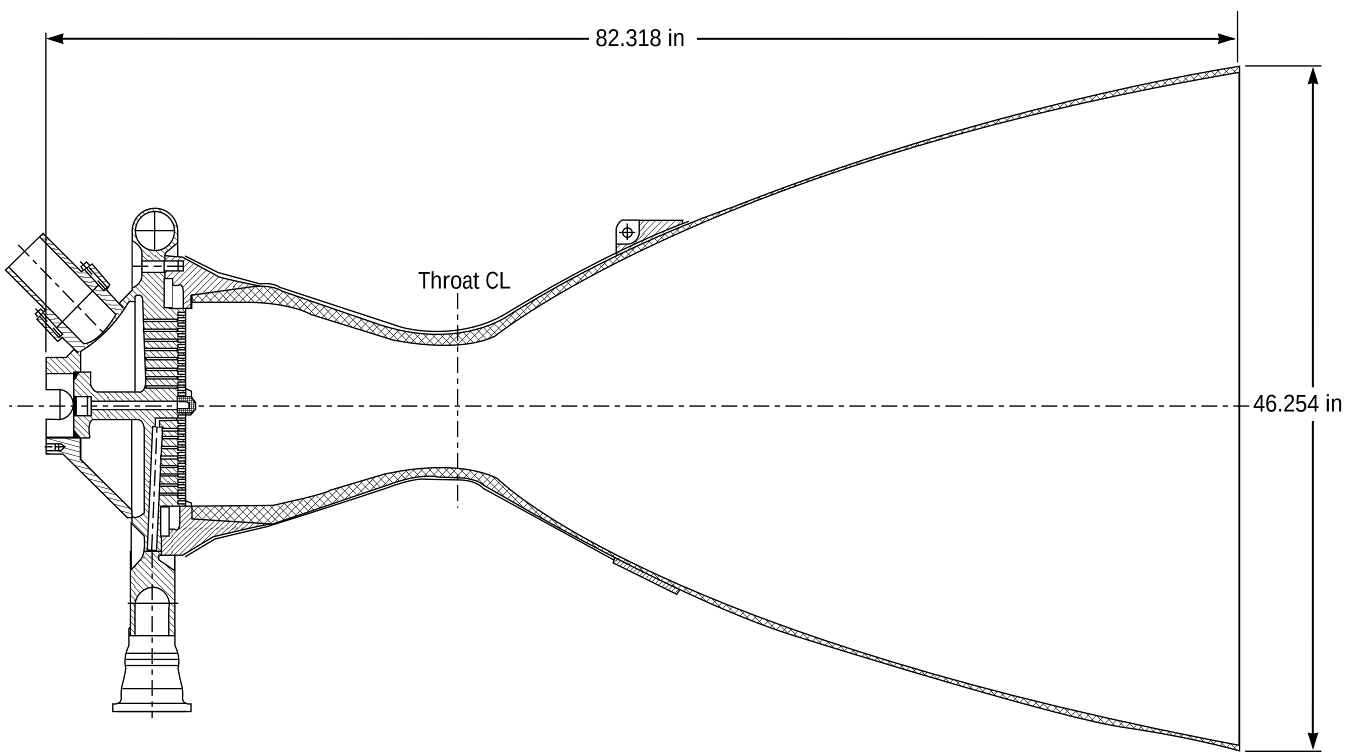

FIGURE 38.—Fastrak II cross section.